

ABSTRACT

The performance of an acoustic filter (or muffler) is measured in terms of one of the following parameters: Insertion Loss (IL), Level difference (LD) and Transmission loss (TL). All these three parameters may be evaluated in terms of the four-pole or transfer matrix parameters. Appropriate experimental setups have been designed and developed and practical considerations are described. Measured values of TL are compared with the analytically predicted values. It is shown that the Two-Source-Location method is relatively the best. To start with, the matrix analysis of conical concentric tube resonators is validated experimentally. The effect of mean flow is investigated. The experimental setup is specially designed to measure the pressure transfer function across the test muffler. It is shown that there is reasonably good agreement between the predicted values of the transfer function and the measured ones for incompressible mean flow as well as stationary medium.

To measure insertion loss of muffler, one needs to calculate the source impedance. The internal impedance of a sound source can be measured using direct or indirect methods. The four-load SPL measurement method is one such indirect method wherein there are three nonlinear equations in terms of two unknowns which makes one of the equations redundant. This leads to erroneous results. To overcome this inherent weakness, two alternatives multi-load methods have been offered in the literature; namely, the least squares and the direct least squares method, to analyze the measured data used for four (or more) different loads. These two methods produce better results than the four-load SPL measurement method used earlier. These measurement methods have been tested on a loudspeaker to measure its source impedance and the results are validated with a known additional acoustic load.

Simple expansion chambers, the simplest of the muffler configurations, have very limited practical application due to the presence of periodic troughs in the transmission loss (TL) spectrum which drastically lower the overall TL of the muffler. Many of the present days automobile exhaust systems make use of the extended tube mufflers, often with perforated ducts because of their low back pressure and good acoustic performance. Tuned extended inlet and outlet can be designed to nullify three-fourths of these troughs, making use of the plane

wave theory. However, these cancellations would not occur unless one altered the geometric lengths for the extended tube and perforated tube resonators in order to incorporate the effect of the evanescent higher-order modes (multidimensional effect) through end corrections or lumped inertance approximation at the area discontinuities or junctions. This is investigated here experimentally as well as numerically (through use of 3-D FEM software) for a moving medium as well as stationary medium. The effect of temperature on the end corrections is also investigated.

These tuned extended-tube chambers, however, suffer from the disadvantages of high back pressure and aerodynamic noise generation at the area discontinuities. These two disadvantages can be overcome by means of a perforated bridge between the extended inlet and the extended outlet. One dimensional control volume approach is used to analyze this muffler configuration. It is validated experimentally making use of the two-source-location method, which is proven to be the best method available to us. It is thus shown that the inertance of holes plays a role similar to the lumped inertance generated by evanescent 3-D modes at the terminations of the quarter wave resonators in the case of the double-tuned extended tube chambers. The effect of mean flow is also investigated. The resultant transfer matrix is then used to carry out a systematic parametric study in order to arrive at empirical expressions for the differential lengths as well as the end corrections. Thus, an extended concentric tube resonator can be tuned such that the first three troughs that characterize the corresponding simple chamber transmission loss (TL) curve may be eliminated making use of the proposed procedure. In fact, the entire TL curve at low and medium frequencies may be substantially lifted, making the tuned extended concentric tube resonator a viable design option.